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MECHANICAL REFRIGERATION

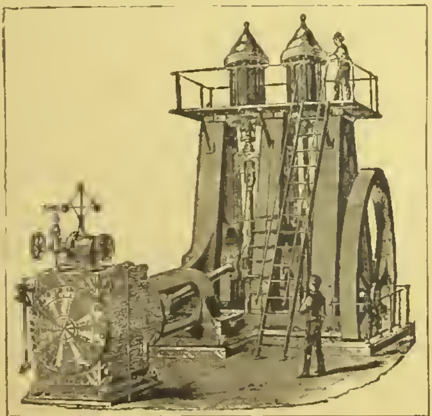
-BY THE-

PROCESSES AND APPARATUS

-OF-

THE DE LA VERGNE

REFRIGERATING MACHINE CO.,



MANUFACTURERS OF

REFRIGERATING AND ICE MACHINES

AND OF

ANHYDROUS AMMONIA.

OFFICE AND WORKS:

Foot of East 138th Street (Port Morris),

NEW YORK.

JOHN C. DE LA VERGNE, President.
LOUIS E. DE LA VERGNE, Vice-President.
C. H. CONE, Secretary.

NEW YORK:
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Office and Works of the De La Vergne Refrigerating Machine Co.

TO THOSE SEEKING A PERFECT SYSTEM OF ARTIFICIAL REFRIGERATION.

In presenting this new edition of our pamphlet to the public interested in mechanical refrigeration, we call particular attention to one great change we have introduced since the issue of our last edition. This is the double-acting compressor. While the fundamental principles of our machines and system, so far as they relate to the expansion and compression of the ammonia, have remained the same—and we may say, to-day, will remain the same in future—and while the general style and appearance of the machine has likewise undergone no change, yet we have for many years experimented on many different forms of double-acting compressors, which would be capable of handling the ammonia equally well on both sides of the piston, in connection with our system of oil-circulation. The great advantage offered by a gas-pump which would do twice the work with hardly any increase in friction was something to be worked for. The result of our labors has been a double-acting compressor, which in every detail of its working is equal to our old single-acting compressor, does double the work, and saves one-eighth of the power to operate it

over a single-acting compressor of the same capacity. In addition to this advantage, the cost of our machine is greatly reduced, and the space which the machine occupies is the same for a doubled capacity.

The condensers have been made considerably lower than in former years. By a large series of experiments we have found that the high condensers were only partly efficient in absorbing the heat from the gas, *i. e.*, only part of the pipes did actual cooling work, while the balance remained inactive. This has reduced the height of the condensers about nine feet, which is a gain in so far as the condenser-room thereby needs to be so much less in height.

The engine-room connections have been simplified by abolishing the low-pressure oil-tank. The latter has been found superfluous when the oil is injected under pressure; which gives us a slight advantage over our old system of charging the oil into the compressor under the suction or back-pressure of the machine.

The pipe-system, with its cocks and fittings, has undergone no change, but by adding quite a number of special patterns we are enabled to construct the pipe-system in a more perfect and pleasing manner.

The construction of the pressure-tank with baffle-plates, which we use on all our larger machines, has made the separation of the oil so perfect that only traces of it are carried over into the separating-tank.

The list of customers, which will be found in this circular, shows what we have accomplished since our last issue, about three years ago. In this time we have added

to it 150 machines with an aggregate capacity of about 8,000 tons per day, or an average of fifty-three tons per machine. All these machines are in operation, give perfect satisfaction, and may be inspected at any time; but the best time is during the summer, when they are in constant operation. It will also appear from the list, that we have added to our customers the proprietors of a large number of packing-houses and abattoirs, of cold-storage houses, ice factories, chemical works, hotels and restaurants, chocolate factories, steamships, and wineries.

We have added to the eight original patents, under which we commenced to work, a large number of others by purchase, and we shall continue to protect our rights under them, as well as the rights of our customers to use them, whenever necessity arises.

In our new factory, a cut of which will be found on one of the first pages of this pamphlet, we are enabled to turn out the most perfect work. By having added a large number of special tools, we are in a position, not only to manufacture our machines and pipe-system in a superior manner, and at a reduced cost, but we have also quadrupled our capacity, and are still increasing it this summer by the building of a large erecting-shop.

The result of all these exertions on our part has been the successful introduction, not only of our machines, but also of our system of refrigeration by direct expansion. In spite of the strenuous efforts of many of our competitors to disparage this system, we are constantly driving forward in this direction, and are adding ad-

mirers of the system to our list of customers. *Not one who has adopted it has ever returned to the use of Brine!*

It may be more satisfactory to those unfamiliar with the subject if we first submit a brief statement of the principles and processes involved in cold-producing machines.

The processes are exceedingly simple, and substantially consist of a cycle, or round, of three operations, following each other in rotation, and which are practically the same in almost all the refrigerating machines now in use.

THEORY OF MECHANICAL REFRIGERATION.

Having first selected the refrigerating or heat-absorbing agent to be used, such as ammonia, ether, sulphurous oxide, etc., this agent is charged into the machine, and afterward passed through the round of the three operations just alluded to, which are as follows:

1. *Compression.*

The agent in gaseous form is compressed to a pressure varying in the case of ammonia from 125 to 175 lbs. per square inch and depending upon the temperature of the condensing water used, either mechanically or otherwise, in order to prepare it for the second operation. During the compression, heat is developed in proportion to the amount of pressure exerted upon the gas, or to the relative volume to which it has been reduced.

Expressed popularly, heat is squeezed out of the gas, and can then be carried away by the condensing water.

2. *Condensation.*

The heat developed in the above operation is withdrawn from the compressed gas by forcing it through coils of pipe while said coils are in contact with cold water ; the heat being transferred to the water surrounding the coils. When this point is reached the gas is ready to assume the liquid condition, and in so doing it gives off additional heat to the surrounding water, as explained more fully hereafter.

3. *Expansion.*

The liquefied gas thus obtained is allowed to enter coils of pipe so placed that the substance to be cooled (air, water, brine, beer, etc.) can be brought into contact with them, the pressure in the interior of these coils being maintained at a lower point than that required for retaining the gas in the liquid state. The liquefied gas, upon entering said coils, re-expands, and extracts from the pipes and the substances surrounding the pipes the same quantity of heat that was previously given up by the gas to the water used during the period of condensation and liquefaction. The gas, having performed in this last operation its refrigerating work, is now ready to repeat the same cycle of operations.

Modifications of the above, and several auxiliary processes, have been introduced in the various machines of different inventors ; still the general principles remain the same, the round of operations above cited being essential to form a complete cycle.

From the above, it will be readily understood that a refrigerating machine consists of three series of parts, each corresponding to one of the above operations:

1st. *A compression side*, in which the gas is compressed, either mechanically or otherwise.

2d. *A condensing side*, generally consisting of coils of pipe, in which the compressed gas circulates, parts with its heat, and liquefies; and

3d. *An expansion side*, consisting also of coils of pipe, in which the gas re-expands and performs the refrigerating work.

In order to render the operation continuous, these three sides or parts are connected together, the gas passing through them in the order named.

The gas is drawn through the expansion coils by the pumps at a pressure varying from 10 to 30 pounds above that of the atmosphere, where ammonia is in use, and is then forced into the condensers, where a pressure of 125 to 175 pounds per square inch usually exists; here liquefaction takes place, and the resulting liquefied gas is allowed to flow to a stop-cock having a minute opening, which separates the compression from the expansion side of the plant.

The expansion side consists of coils of pipe similar to those of the condensing side, but used for the reverse operation, which is the absorption of heat by the liquefied gas, instead of the expulsion of heat from it, as in the former operation.

Heat is conducted through the expansion or cooling coils to, and is absorbed by, the expanding liquefied gas

within such coils, for the reason that they are connected to the suction or low-pressure side of the apparatus, from which the pumps are continually drawing the gas and thereby reducing the pressure in said coils, as already stated, to a pressure of 10 or 30 pounds above the atmosphere; it being kept in mind that liquefied ammonia, in again assuming a gaseous condition, at atmospheric pressure and a temperature of 60° Fahr., expands a thousand times, and has the power or capacity of reabsorbing, upon its expansion, a quantity of heat equal in amount to that originally held and discharged from it during liquefaction. The liquefied gas, entering these coils through the minute opening of the stop-cock above referred to, is suddenly relieved of a pressure of 125 to 175 pounds, the amount requisite to maintain it in a liquid condition, when it begins to boil, and in so doing passes into the gaseous state. To do this it must have heat, which can be supplied only from the substances surrounding the pipes, such as air, brine, water, wort, etc. As a natural result the surrounding substances are reduced in temperature, or cooled; the quantity of heat taken up by the gas being the same as that which was expelled from it during its liquefaction in the condensers. It is apparent, from the foregoing, that if the expansion coils are placed in an insulated room, that room will be refrigerated; also, if brine or wort is brought in contact with the surface of the coils, they also will be reduced in temperature; and that brine so cooled can be used to refrigerate an insulated room by simply forcing it to circulate through pipes or gutters suspended in the same.

Either of the above methods can be applied to the refrigeration of breweries, packing-houses, etc., and for the manufacture of ice, the same gas being used over and over again to perform the same cycle of operations.

As said before, various modifications of the above, as well as auxiliary processes, have been introduced by patentees and builders in their several machines; but the principles already described are the same in all, the difference being in their application.

MECHANICAL COMPRESSION.

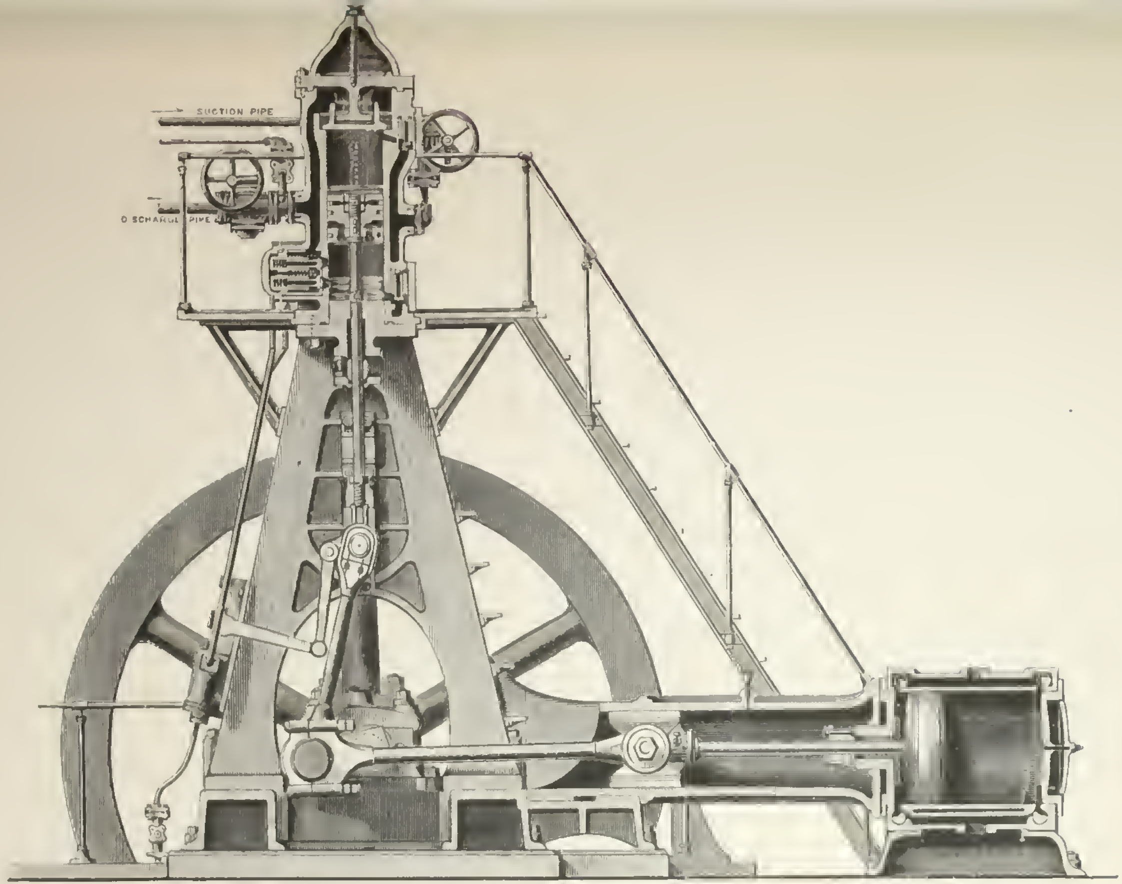
The mechanical difficulties encountered in pumping a gas of the extreme tenuity of ammonia may be stated as threefold in number, and are as follows:

1. *The Imperfect Discharge of the Gas from the Pump.*

This it was found impossible to overcome until we perfected our present compressor. As a clearance must necessarily be left between the piston and the cylinder-head, only a portion of the compressed gas was expelled at each stroke; that remaining re-expanded with the reverse motion of the piston, produced a pressure against the incoming charge of gas, and resulted in a loss of power and efficiency.

2. *Leaky Stuffing-Boxes, Pistons, and Valves.*

In ordinary compressors the motion of the piston and rod, at each alternate stroke, would either introduce



Sectional View of Double-Acting Machine.

air into the pump, providing the internal pressure was less than that of the atmosphere, or draw out and waste a volume of the refrigerating gas, and it was impossible to pack a pump piston and gland sufficiently tight to prevent these difficulties. In some cases where the attempt was made, the power required to overcome the friction of the stuffing-box thus tightened was found more than sufficient to do the entire work of compression. Again, working against constant pressures of 125 to 150 lbs. necessitated the use of a tight piston, the least wear causing considerable leakage of gas past the piston into the adjoining pump chamber. Similar difficulties were also encountered with the valves, causing the gas to re-enter the pump past the discharge-valves, or to be returned to the suction side past its corresponding valves. It will be well to mention here that, to obviate the leaky stuffing-box, some makers have resorted to the device of ejecting a stream of water against the piston-rod and stuffing-box, ostensibly to cool the rod, but in reality to absorb the gas leaking past the gland, thus rendering a great source of loss inapparent, which loss, in connection with a leaky piston and valves, materially reduces the efficiency of the pump.

3. *The Heat of Compression.*

The mechanical energy which the compressor piston exerts upon the gas is converted into heat, which by expanding a tight packing of the piston causes friction; while on the other hand a loose packing of the piston, or its eventual wear, allows the gas to slip past.

The heat of compression expands the gas during com-

pression, thereby increasing its volume, which necessitates an opening of the discharge valve prior to the time that it would open were the gas cooled during compression.

The work spent in effecting this prior discharge of the increased volume of gas is work lost.

To avoid these losses, and to obtain a higher efficiency in compressors other than ours, the device is resorted to of flooding the external portion of the cylinder with water, and also of circulating a stream of water through the piston and piston-rod ; but in such cases the thickness of metal required in the construction of the pumps and piston is so great that the cooling effect is only an approach to that which would effectually prevent such losses. In fact, this cooling only benefits the walls of the compressor, while the gas itself is practically not at all reduced in temperature.

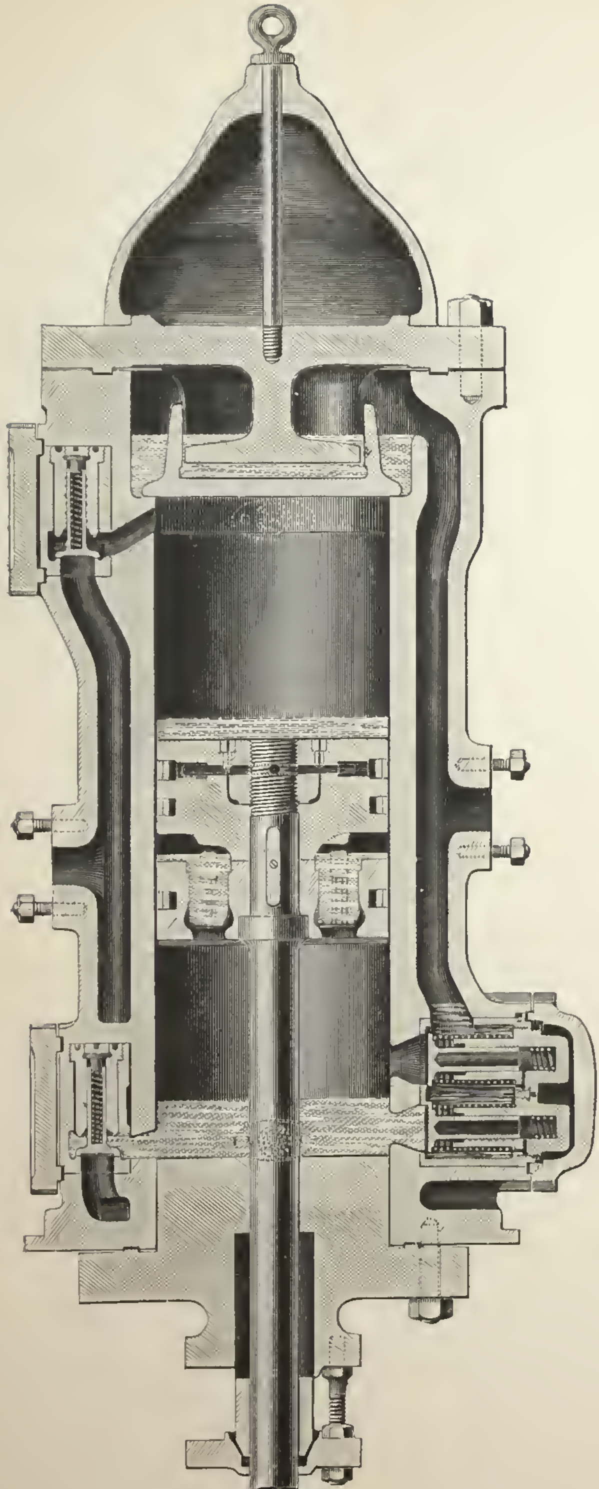
The mechanical difficulties enumerated and described were of such a serious nature that, until we perfected our present compressor, gas pumps or compressors had attained an efficiency of only 50 to 70 per cent. of their theoretical duty. They wore rapidly, requiring frequent reboring, repacking, and repairs, and were very defective, being excessive consumers of fuel, and losing an enormous quantity of expensive gas, and to such an extent as to make them too expensive to be practical, even though the first cost of the apparatus was relatively low in price.

OUR PATENTED SYSTEM.

To make mechanical refrigeration a success, it is essential—1st, to discharge the entire volume of the gas entering the compressors; 2d, to prevent all leakage past the stuffing-box, piston, and valves; and 3d, to extract the heat from the gas during compression. All this we accomplish by a simple device, one for injecting into the compressor, at each stroke, a certain quantity of lubricating liquid, which effectually seals the stuffing-box, piston, and valves, fills all clearances, and takes up the heat developed during compression.

OUR DOUBLE-ACTING COMPRESSOR.

For a number of years we have been experimenting to solve the problem of constructing a double-acting compressor which would handle the gas in connection with our system of oil circulation as well on the up *and* down stroke as the single-acting compressor does on the up stroke. It is apparent that a double-acting pump is more advantageous—providing it is well constructed—because it handles double the amount of gas with every revolution of the crank-shaft that a single-acting com-



Sectional View of Double-Acting Compressor.

pressor does, which has the same diameter and the same stroke. The moving parts, such as cross-head, piston, piston-rod, and connecting-rod being the same for either a single or a double acting compressor, the *friction will be the same for all these parts, while double the work is being effected.* To overcome friction means power expended—*power wasted*—and in our case, viz., in a machine with two gas-compressors it means a saving of one-eighth of the whole power used for compressing the gas. Another advantage is the cheapening of the machine through the fact that one double-acting compressor will do the work of two single-acting ones of the same size.

In attempting the construction of a double-acting compressor the oil-circulation proved a serious drawback to the proper discharge of the gas on the lower side of the piston, and still we could and would not give it up, because this would have meant an inferior pump. In the ordinary form of double-acting compressors the discharge-valves at the lower end are placed either on the side or in the lower head. In either case the oil is discharged on the down stroke *before* all the gas has left the pump—and this is wrong. The oil must be discharged *after* all the gas is gone, because otherwise re-expansion takes place, and this means loss of efficiency of the pump. We have avoided this difficulty in the following manner:

At the lower end of the compressor there are two discharge-valves placed on the side—one above the other. On the down stroke either of the valves or both

may open until the piston covers the upper one, when only the lower one is open to the condenser. In the further course of the piston and as soon as the lower valve is also closed, the upper one is in communication with an annular chamber contained in the piston. This chamber has valves in its bottom, which open into it as soon as all other outlets from the lower side of the piston are closed (they open a little harder than the discharge-valves on the side); and now the gas will all go out through the piston, and after the gas the oil will follow, thus permitting no gas to remain on the lower side after the completion of the down stroke. It will be seen that in this manner the very important oil-system of our machine is retained, and that the lower side of the pump works as well as the upper, while the oil effectually seals the stuffing-box in spite of the higher pressure on it at the end of the down stroke.

The machines with this style of compressor have been in operation, some of them, nearly two years, have all worked to our utmost satisfaction, and we are now recommending them as superior to the single-acting machines on account of the saving in power and greater cheapness.

A patent on this compressor has been granted to Mr. Louis Block, the chief-engineer of our company.

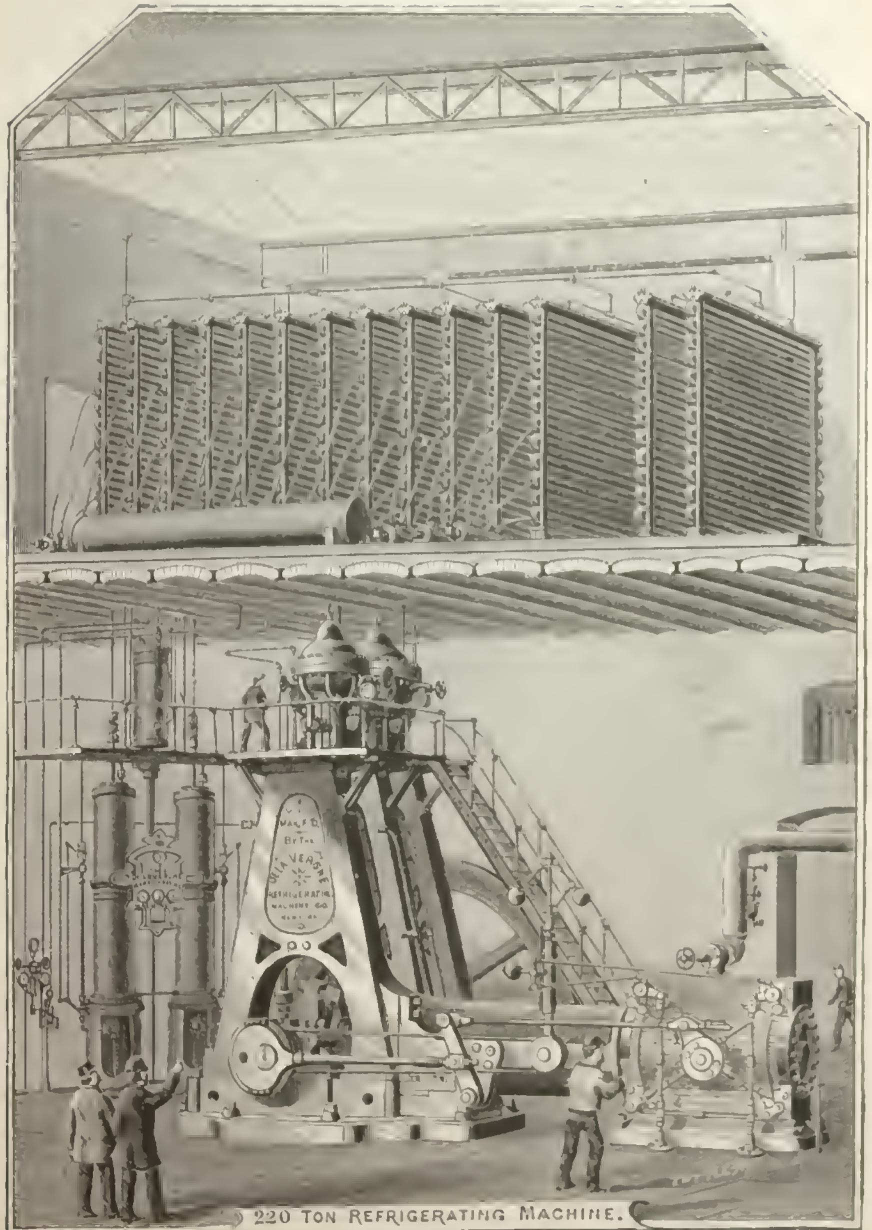
APPLICATION--COOLING ABATTOIRS AND PACKING-HOUSES.

As was the case in breweries, we had to overcome the same prejudice in abattoirs regarding our direct expansion system. Packers were even a little more afraid to introduce the direct pipe-system into their chill-rooms than brewers were to put it in their fermenting-rooms. We have, however, made considerable progress, also, as to the industry that deals with the preservation of meat; and as we have no failure or accident to record since we introduced our system into packing-houses eight years ago confidence in it is now well established.

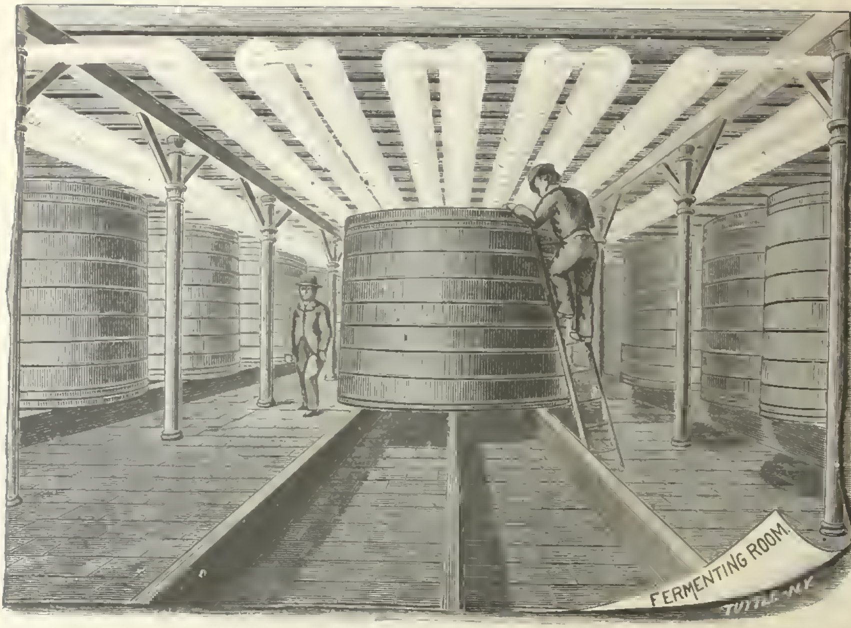
It will be of interest in order to allay the fears of the influence of ammonia on fresh meat to quote an article on this subject published in the issue of *The Scientific American* of July 20, 1889. The article is as follows:

AMMONIA AS AN ANTISEPTIC.

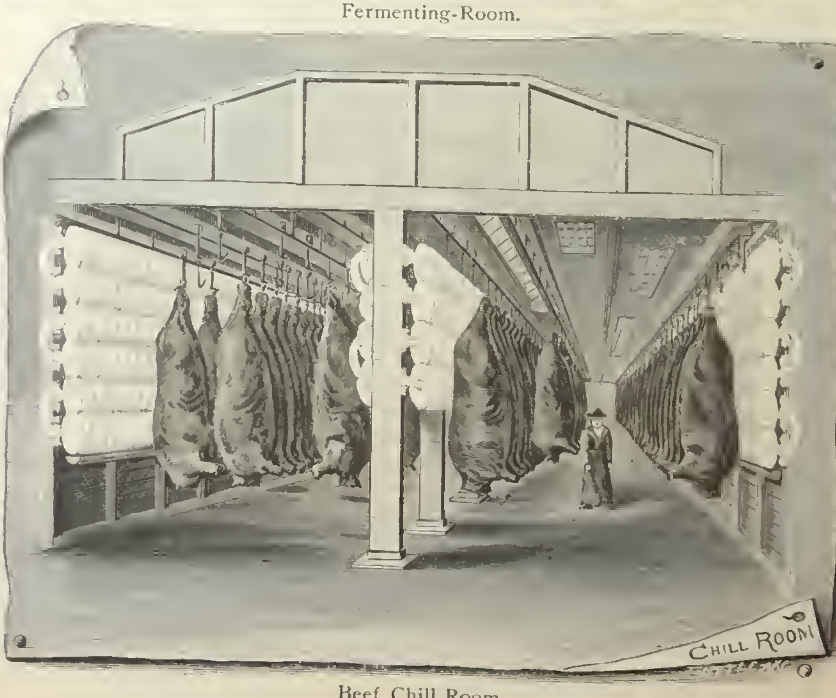
Some years ago Dr. B. W. Richardson, in a communication to the Medical Society, called attention to the antiputrescent properties of ammonia, and showed that blood, milk, and other alterable liquids could be preserved for a long time by adding to them certain quantities of solution of ammonia; and solid substances, such as flesh, by keeping them in closed vessels filled with ammonia gas. Some doubts that would appear to have been raised as to the results reported, on the ground that ammonia was itself a product of decomposition, induced Dr. Gottbrecht, of the University of Greifswald, to repeat the experiments with the re-



220-ton Refrigerating Machine, with Condensers above.



Fermenting-Room.



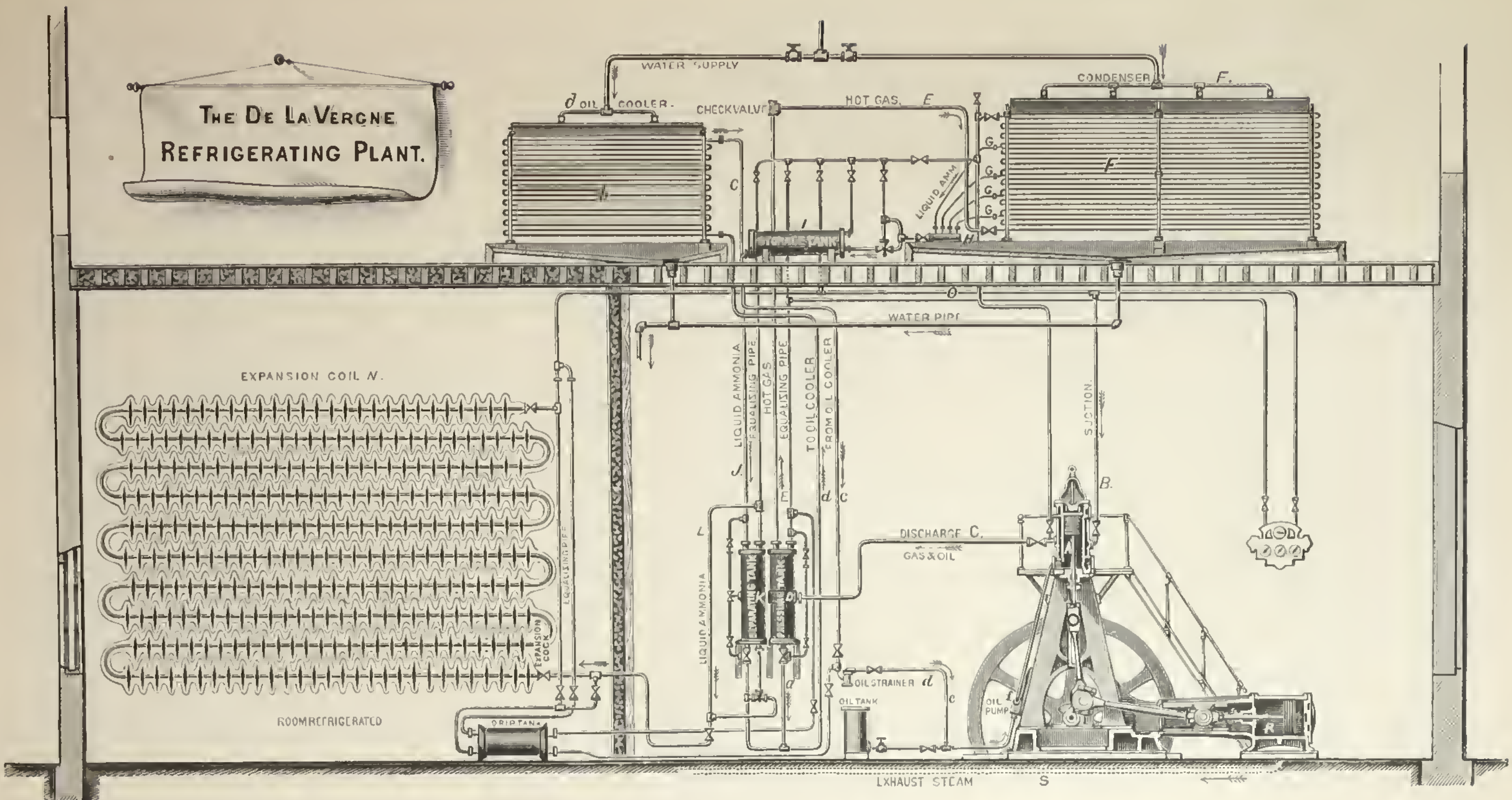
Beef Chill Room.

Hog Chill Room.

sult of practically confirming all Dr. Richardson's statements. After some preliminary experiments, in which animal matter placed in 5% ammonia solution was found free from putrescence after nearly two years, ammonium carbonate was used in place of the free alkali for the sake of convenience. The first experiment made with the washed intestines of freshly killed pigs showed the power of ammonium carbonate to retard putrefaction to be directly dependent upon the concentration of the solution, a 1% solution retarding it until the third day, a 10% solution until about the sixtieth day. When added to gelatine in which putrefaction had already been set up by inoculation, it was found that a 5% solution so modified the conditions that the putrescence ceased, and a 2½% solution inhibited the development of bacteria, so that the liquefaction of the gelatine was practically stopped. Other experiments showed that in an atmosphere impregnated with ammonium carbonate meat could be kept for six months, and at the end of that time remain nearly unaltered.

In the woodcuts accompanying this issue, will be found a sectional view of our machine, showing the latest style; also a cut of a 220-ton machine, with condensers and oil-cooler on the floor above—and two cuts representing fermenting-room of a brewery, and chill-room for beeves as arranged for an abattoir. The expansion-coils in the latter we also, if we have room for it, place in a separate chamber above, as shown in cut of hog chill-rooms, with warm and cold air flues so arranged that a very excellent circulation of air is the result.

The cut on the following page represents our machine in connection with the direct-expansion system, and by following the arrows, and noting the character of the pipes (shown in print), the course of the ammonia as well as of the oil can be traced throughout the whole circuit, from their leaving the compressors jointly



Refrigerating-Plant—New System.

to their returning to them separately. The stages of separation in the first pressure-tank, the cooling of the oil and its return to the oil pump, and the liquefaction of the gas in the condensers, the collection of the liquid in the storage-tank, and the second separation of it from the traces of oil carried through the condensers, the injection of the liquid ammonia into the expansion-coils, where the cooling is accomplished, and the return of the expanded gas to the compressor, are all clearly shown.

A full description of our system and apparatus will be sent to persons applying for the same.

Correspondence from parties desirous of contracting for a refrigerating-plant is solicited, and estimates and proposals will be promptly furnished, free of charge, after their requirements are made known to us.

THE DE LA VERGNE REFRIGERATING MACHINE CO.,
Foot of East 138th Street,
New York.

The sizes of machines for which we now have the patterns, and which may be ordered from us at any time, are the following:

MACHINES WITH SINGLE-ACTING COMPRESSORS.

Compressors.	Steam Cylinders.	Horse-power required.	Capacity of Machines in Ice Melted every 24 hours.	Capacity of Machines in Ice Manufactured every 24 hours.
One 6 x 10	One 7 x 10	3 H.-P.	2 Tons.	1 Ton.
Two 6 x 12	" 9 x 12	6 "	4 "	2 Tons.
" 8 x 16	" 12 x 16	13 "	9 "	5 "
" 9 x 16	" 13 x 16	17 "	12 "	7 "
" 10 x 20	" 16 x 20	25 "	18 "	10 "
" 12 x 24	" 18 x 24	47 "	35 "	20 "
" 14 x 28	" 22 x 28	66 "	50 "	30 "
" 16 x 32	" 26 x 32	100 "	75 "	45 "
" 18 x 36	" 32 x 36	140 "	110 "	65 "

MACHINES WITH DOUBLE-ACTING COMPRESSORS.

Compressors.	Steam Cylinders.	Horse-power required.	Capacity of Machines in Ice Melted every 24 hours.	Capacity of Machines in Ice Manufactured every 24 hours.
One 6 x 10	One 9 x 10	6 H.-P.	4 Tons.	2 Tons.
Two 6 x 12	" 12 x 12	12 "	9 "	5 "
" 8 x 16	" 16 x 16	23 "	18 "	10 "
" 9 x 18	" 18 x 18	31 "	25 "	15 "
" 10 x 20	" 20 x 20	42 "	35 "	20 "
" 11 x 22	" 22 x 22	60 "	50 "	30 "
" 12 x 24	" 24 x 24	77 "	65 "	40 "
" 14 x 28	" 28 x 28	119 "	100 "	60 "
" 16 x 32	" 32 x 32	180 "	150 "	90 "
" 18 x 36	" 36 x 36	250 "	220 "	130 "

The above capacities are based on 40 revolutions per minute.

LIST OF CUSTOMERS.

January 1, 1890.

The De La Vergne Refrigerating Machine Co.,

Foot of East 138th Street, NEW YORK CITY.

BREWERIES.

Name.	Address.	Number of Machines.		Total Refrigeration.	Year of Completion.
Jacob Ruppert	New York	One	110-ton	=110 tons	1884
Jacob Ruppert—Second Order	New York	Two	110 "	220 "	1885
George Ehret	New York	One	110 "	110 "	1885
George Ehret—Second Order	New York	Two	110 "	220 "	1885
William J. Lemp	St. Louis, Mo.	Two	110 "	220 "	1888
William J. Lemp—Second Order	St. Louis, Mo.	One	110 "	110 "	1889
Bernheimer & Schmid	New York	One	220 "	220 "	1888
†Anheuser-Busch Brewing Ass'n	St. Louis, Mo.	One	110 "	110 "	1886
Anheuser-Busch Brewing Ass'n—Second Order	Kansas City, Mo	One	12 "	12 "	1886
†Anheuser-Busch Brewing Ass'n—Third Order	St. Louis, Mo.	One	110 "	110 "	1189
Anheuser-Busch Brewing Ass'n—Fourth Order	Dallas, Texas	One	4 "	4 "	1889
(For Fifth and Sixth orders from Anheuser-Busch Brewing Association, see Artificial Ice Plants.)					
Budweiser Brewing Co., Lim'd	Brooklyn, N. Y.	One	110 "	110 "	1886
*L. Schlather Brewing Co	Cleveland, Ohio	One	110 "	110 "	1888
Hinckel Brewing Co	Albany, N. Y	One	100 "	100 "	1889
Joseph Schlitz Brewing Co.—First Order	Memphis, Tenn.	One	4 "	4 "	1886
Joseph Schlitz Brewing Co.—Second Order	Milwaukee, Wis.	One	100 "	100 "	1890
Eberhardt & Ober Brewing Co	Pittsburgh, Pa.	One	100 "	100 "	1890
†Hyde Park Brewery Co	St. Louis, Mo	One	75 "	75 "	1886
†Pabst Brewing Co	Milwaukee, Wis.	One	75 "	75 "	1886
*John Wieland Brewing Co	San Francisco, Cal.	One	75 "	75 "	1889
Falk, Jung & Borchert Brewing Co.	Milwaukee, Wis.	One	75 "	75 "	1889
Ballantine & Co	Newark, N. J.	One	64 "	64 "	1882
Ballantine & Co.—Second Order	Newark, N. J.	One	110 "	110 "	1886
Ballantine & Co.—Third Order	Newark, N. J.	Two	100 "	200 "	1890
†Bergner & Engel Brewing Co	Philadelphia, Pa.	One	50 "	50 "	1884
†Bergner & Engel Brewing Co.—Second Order	Philadelphia, Pa.	One	50 "	50 "	1885
†Bergner & Engel Brewing Co.—Third Order	Philadelphia, Pa.	One	110 "	110 "	1888
†Bartholomay Brewing Co	Rochester, N. Y.	One	50 "	50 "	1886
Bartholomay Brewing Co.—Second Order	Rochester, N. Y.	Two	50 "	100 "	1887

Name.	Address.	Number of Machines.		Total Refrigeration.	Year of Completion.
Rochester Brewing Co.	Rochester, N. Y.	One	50-ton	= 50 tons	1888
Rochester Brewing Co. — Second Order	Rochester, N. Y.	One	100 "	100 "	1889
Z. Wainwright Brewing Co.	Pittsburgh, Pa.	Two	65 "	130 "	1890
Macon Brewing Co.	Macon, Ga	Two	65 "	130 "	1890
S. Liebmann's Sons	Brooklyn, N. Y.	Two	50 "	100 "	1883
Wainwright Brewery Co.	St. Louis, Mo.	Two	50 "	100 "	1884
Rubsam & Horrman	Staten Island	Two	50 "	100 "	1885
Conrad Stein	New York	Two	50 "	100 "	1886
Beadleston & Woerz	New York	Two	50 "	100 "	1885
*Jacob Hoffmann Brewing Co.	New York	Two	50 "	100 "	1887
J. & P. Baltz Brewing Co.	Philadelphia, Pa.	Two	50 "	100 "	1887
Leonhard Eppig	Brooklyn, N. Y.	Two	50 "	100 "	1887
Crescent City Brewing Co.	New Orleans, La	Two	50 "	100 "	1888
Louis Bergdoll Brewing Co.	Philadelphia, Pa.	One	64 "	64 "	1882
Louis Bergdoll Brewing Co.—Second Order	Philadelphia, Pa.	Two	50 "	100 "	1885
The Bartholomae & Leicht Brewing Co.	Chicago, Ill.	Two	50 "	100 "	1889
Otto Huber	Brooklyn, N. Y	Two	35 "	70 "	1881
Otto Huber—Second Order	Brooklyn, N. Y.	One	50 "	50 "	1885
Gottfried Krueger	Newark, N. J	Two	35 "	70 "	1883
Gottfried Krueger—Second Order	Newark, N. J	One	50 "	50 "	1885
Burr, Son & Co.	New York	Two	35 "	70 "	1880
Obermeyer & Liebmann	Brooklyn, N. Y	Two	35 "	70 "	1884
Peter Hauck & Co.	Newark, N. J.	Two	35 "	70 "	1884
Christian Schmidt	Philadelphia, Pa.	Two	35 "	70 "	1885
†A. Finck & Son	New York	Two	35 "	70 "	1885
Franz J. Kastner	Newark, N. J.	Two	35 "	70 "	1885
Christian Weyand	Buffalo, N. Y.	Two	35 "	70 "	1886
C. Trefz	Newark, N. J.	Two	35 "	70 "	1886
J. H. Von der Horst & Son	Baltimore, Md.	Two	35 "	70 "	1884
Monroe Eckstein	Staten Island	Two	35 "	70 "	1887
M. Groh's Sons	New York	Two	35 "	70 "	1887
Weckerling Brewing Co.	New Orleans, La.	Two	35 "	70 "	1888
Pelican Brewing Co.	New Orleans, La.	Two	35 "	70 "	1888
Frederick Koehler & Co.	Erie, Pa.	Two	35 "	70 "	1890
Suffolk Brewing Co.	Boston, Mass.	One	65 "	65 "	1890
American Brewing Co.	Chicago, Ill.	One	65 "	65 "	1890
Northwestern Brewing Co.	Chicago, Ill.	One	65 "	65 "	1890
H. B. Scharmann	Brooklyn, N. Y.	One	50 "	50 "	1883
H. B. Scharmann—Second Order	Brooklyn, N. Y.	One	50 "	50 "	1888
Claus Lipsius	Brooklyn, N. Y.	One	50 "	50 "	1883
Claus Lipsius—Second Order	Brooklyn, N. Y.	One	50 "	50 "	1885
William Ulmer	Brooklyn, N. Y.	One	50 "	50 "	1886
William Ulmer—Second Order	Brooklyn, N. Y.	One	50 "	50 "	1886
H. & J. Paff	Boston, Mass.	One	50 "	50 "	1884
H. & J. Paff—Second Order	Boston, Mass.	One	50 "	50 "	1885
Henry Muller	Philadelphia, Pa	One	50 "	50 "	1884
Henry Muller—Second Order	Philadelphia, Pa.	One	50 "	50 "	1886
Ph. Zang & Co.	Denver, Col.	One	50 "	50 "	1886
Ph. Zang & Co—Second Order	Denver, Col.	One	50 "	50 "	1887
*Jos. Schnaider's Brewing Co.	St. Louis, Mo	One	50 "	50 "	1886
*Jos. Schnaider's Brewing Co.—Second Order	St. Louis, Mo	One	50 "	50	1887
*H. Grone Brewery Co.	St. Louis, Mo	One	50 "	50	1886
*H. Grone Brewery Co.—Second Order	St. Louis, Mo	One	50 "	50 "	1888

Name.	Address.	Number of Machines.	Total Refrigeration.	Year of Completion.
Jung Brewing Co.	Cincinnati, O.	One	50-ton. . = 50 tons	. . 1886
Jung Brewing Co—Second Order.	Cincinnati, O.	One	50 " . . 50 "	. . 1886
Christian Heurich	Washington, D. C.	One	50 " . . 50 "	. . 1885
John Roessle	Boston, Mass.	One	50 " . . 50 "	. . 1885
†H. Clausen & Son Brewing Co.	New York	One	50 " . . 50 "	. . 1887
B. Stroh Brewing Co.	Detroit, Mich.	One	50 " . . 50 "	. . 1887
Fred. Miller Brewing Co.	Milwaukee, Wis.	One	50 " . . 50 "	. . 1887
Fred. Miller Brewing Co.—Second Order	Milwaukee, Wis.	One	50 " . . 50 "	. . 1889
A. Griesedieck Brewing Co.	St. Louis, Mo.	One	50 " . . 50 "	. . 1888
*Haffenreffer & Co.	Boston, Mass.	One	50 " . . 50 "	. . 1888
Valentine Loewer	New York	One	50 " . . 50 "	. . 1888
Ziegele Brewing Co.	Buffalo, N. Y.	One	50 " . . 50 "	. . 1883
National Brewing Co.	San Francisco, Cal.	One	50 " . . 50 "	. . 1888
Jacob Ahles Brewing Co.	New York	One	50 " . . 50 "	. . 1889
Buffalo Brewing Co.	Sacramento, Cal.	One	50 " . . 50 "	. . 1889
(For second order from Buffalo Brewing Co., see Artificial Ice Plants.)				
William Peter	Union Hill, N. J.	One	50 " . . 50 "	. . 1890
D. M. Lyon & Sons	Newark, N. J.	One	50 " . . 50 "	. . 1890
United States Brewing Co.	San Francisco, Cal.	One	50 " . . 50 "	. . 1890
Peter Buckel	New York	One	35 " . . 35 "	. . 1889
George Zett	Syracuse, N. Y.	One	35 " . . 35 "	. . 1889
Hubert Fischer	Hartford, Conn.	One	35 " . . 35 "	. . 1889
Grasser & Brand Brewing Co.	Toledo, O.	One	35 " . . 35 "	. . 1889
Ferd. Munch	Brooklyn, N. Y.	One	35 " . . 35 "	. . 1889
Ferd. Munch—Second Order	Brooklyn, N. Y.	One	35 " . . 35 "	. . 1882
Continental Brewing Co.	Philadelphia, Pa.	One	35 " . . 35 "	. . 1884
Continental Brewing Co.—Second Order	Philadelphia, Pa.	One	35 " . . 35 "	. . 1883
C. Feigenspan	Newark, N. J.	One	35 " . . 35 "	. . 1884
C. Feigenspan—Second Order	Newark, N. J.	One	35 " . . 35 "	. . 1884
Wm. Hill	Newark, N. J.	One	35 " . . 35 "	. . 1886
Wm. Hill—Second Order	Newark, N. J.	One	35 " . . 35 "	. . 1884
Chas. A. King	Boston, Mass.	One	35 " . . 35 "	. . 1886
J. Chr. G. Hupfel Brewing Co.	New York	One	35 " . . 35 "	. . 1884
J. Chr. G. Hupfel Brewing Co.—Second Order	New York	One	35 " . . 35 "	. . 1886
Ernst Bros. Brewing Co.	Chicago, Ill.	One	35 " . . 35 "	. . 1887
Ernst Bros. Brewing Co.—Second Order	Chicago, Ill.	One	35 " . . 35 "	. . 1886
*A. Hupfel's Son	New York	One	35 " . . 35 "	. . 1887
*A. Hupfel's Son—Second Order	New York	One	35 " . . 35 "	. . 1886
George Guenther	Baltimore, Md.	One	35 " . . 35 "	. . 1886
Germania Brewing Co.	Syracuse, N. Y.	One	35 " . . 35 "	. . 1886
W. G. Abbott Brewing Co.	Brooklyn, N. Y.	One	35 " . . 35 "	. . 1886
N. Molter's Sons	Providence R. I.	One	35 " . . 35 "	. . 1887
†J. L. & W. L. Straus	Baltimore, Md.	One	35 " . . 35 "	. . 1887
J. L. & W. L. Straus—Second Order	Baltimore, Md.	One	35 " . . 35 "	. . 1887
Joseph Stoeckle	Wilmington, Del.	One	65 " . . 65 "	. . 1890
Welde & Thomas	Philadelphia, Pa.	One	35 " . . 35 "	. . 1885
San Antonio Brewing Co.	San Antonio, Tex.	One	35 " . . 35 "	. . 1885
Jos. Fallert Brewing Co.	Brooklyn, N. Y.	One	35 " . . 35 "	. . 1888
Jos. Fallert Brewing Co.—Second Order	Brooklyn, N. Y.	One	35 " . . 35 "	. . 1888
Katz Bros.	Paterson, N. J.	One	35 " . . 35 "	. . 1889
M. Winter & Bros.	Pittsburgh, Pa.	One	35 " . . 35 "	. . 1888
Burg & Pfaender	Philadelphia, Pa.	One	35 " . . 35 "	. . 1889

Name.	Address.	Number of Machines.	Total Refrigeration.	Year of Completion.
Miller Brewing Co	Rochester, N. Y.	One	35-ton. . =	35 tons. . 1887
Miller Brewing Co.—Second Order	Rochester, N. Y.	One	15 "	15 " . . [illegible]
Leibinger & Oehm	Newtown, N. Y.	One	35 "	35 " . . 1889
John Schuesler Brewing Co.	Buffalo, N. Y.	One	35 "	35 " . . 1889
Schaefer & Meyer Brewing Co	Louisville, Ky.	One	35 "	35 " . . 1889
Hellmann & Kipp	Waterbury, Conn.	One	35 "	35 " . . 1889
Cincinnati Brewing Co	Hamilton, O.	One	35 "	35 " . [illegible]
Cincinnati Brewing Co.—Second Order	Hamilton, O.	One	65 "	65 1890
*Oppmann Brewing Co.	Cleveland, O.	One	35 "	35 . [illegible]
Schmidt & Bro.	Cincinnati, O.	One	35 "	35 . [illegible]
Union Brewing Co.	Rochester, N. Y.	One	35 "	35 1890
Claussen-Sweeney Brewing Co.	Seattle, W. T.	One	35 "	35 1890
Kalmbach & Geisel	Springfield, Mass.	One	15 "	15 1887
William Smith & Co.	Boston, Mass.	One	15 "	15 . 1887
Liebert & Obert	Manayunk, Pa.	One	15 "	15 . [illegible]
Ph. Schneider Brewing Co.	Trinidad, Col.	One	15 "	15 . [illegible]
Joseph Weibel	New Haven, Conn.	One	15 "	15 . [illegible]
Joseph Kohnle	Philadelphia, Pa.	One	12 "	12 [illegible]
Willibald Kuebler	Easton, Pa.	One	12 "	12 . . 1887
*Guayaquil Lager Beer Brewery Ass'n	Guayaquil, Ecuad.	One	12 "	12 " . . [illegible]
Loebs Bros.	Rochester, N. Y.	One	12 "	12 " . [illegible]
Loebs Bros. (American Brewing Co.)—Second Order	Rochester, N. Y.	One	65 "	65 1890
H. Weidemann Brewing Co.	New Haven, Conn.	One	12 "	12 . . [illegible]
Theo. R. Helb	York, Pa.	One	9 "	9 . 1885
Eckart Bros.	Bridgeport, Conn.	One	9 "	9 . . 1885
Eckart Bros.—Second Order	Bridgeport, Conn.	One	9 "	9 " . 1886
Herrall & Zimmerman	Portland, Ore.	One	[illegible] "	[illegible] " . . 1885
G. Mander	Elmira, N. Y.	One	9 "	9 " . . [illegible]
Theo. Finkenauer	Philadelphia, Pa.	One	9 "	9 " . . 1887
Theo. Finkenauer—Second Order	Philadelphia, Pa.	One	[illegible]	15 . . [illegible]

ABATTOIRS AND PACKING-HOUSES.

Name.	Address.	Number of Machines.	Total Refrigeration.	Year of Completion.
*T. C. Eastman	New York	Two	110-ton. . =	220 tons. . 1884
W. H. Silberhorn	Sioux City, Ia.	Two	50 "	100 " . 1887
Nelson New River Platte Meat Co.	Zaratte, Argentine Republic	One	65 "	65 " . . 1890
Argentine Meat Co., Limited	Colon, Argentine Republic	One	65 "	65 " . . [illegible]
G. Sansinena & Co.	Buenos Ayres, Argentine Republic	One	65 "	65 " . [illegible]
St. Louis Beef Canning Co.	E. St. Louis, Ill.	One	64 "	64 " . [illegible]
East Side Hide Association	New York	One	50 "	50 . . [illegible]
Ryan Brothers	Cincinnati, O.	One	35 "	35 " . . 1887
Rohe & Bro.	New York	One	35 "	35 " . . 1884
*Rohe & Bro.—Second Order	New York	One	9 "	9 " . . 1886
Rohe & Bro.—Third Order	New York	One	35 "	35 " . . [illegible]
*Richard Webber	New York	One	35 "	35 " . . [illegible]
A. Sander & Co.	Cincinnati, O.	One	15 "	15 " . 1886
Hart & Brother	Wilmington, Del.	One	15 "	15 " . 1886
Burkhardt Packing Co.	Denver, Col.	One	15 "	15 " . [illegible]
Arnold Bros.	Chicago, Ill.	One	15 "	15 " . . [illegible]
Arnold Bros.—Second Order	Chicago, Ill.	One	15 "	15 " . . [illegible]
Griffin & McElroy	Bridgeport, Conn.	One	15 "	15 " . . [illegible]
Gebhardt W. Zeiger	Chicago, Ill.	One	12 "	12 " . [illegible]
Wm. Ottmann & Co.	New York	One	15 "	15 " . . 1890
R. D. Waddell	Glasgow, Scotland	One	4 "	4 " . . [illegible]

COLD STORAGE.

Name.	Address.	Number of Machines.		Total Refrigeration.	Year of Completion.
*Quaker City Cold Storage and Warehouse Co.	Philadelphia, Pa.	Two	65-ton	=130 tons	1890
Purfleet Wharf	London, Eng.	Two	40 "	80 "	1888
Leadenhall Market	London, Eng.	One	35 "	35 "	1888
*Washington Market Co.	Washington, D. C.	One	35 "	35 "	1888
Spiers & Pond	London, Eng.	One	4 "	4 "	1888
Fred Hollender & Co.	New York	One	4 "	4 "	1888

HOTELS AND RESTAURANTS.

*Murray Hill Hotel	New York	One	9-ton	=9 tons	1886
*Plaza Hotel	New York	One	9 "	9 "	1890
*Portland Hotel Co.	Portland, Ore.	One	4 "	4 "	1890
Hotel Luehrmann	Memphis, Tenn.	One	2 "	2 "	1889
†Geo. D. Smith (Dairy Kitchen)	New York	One	2 "	2 "	1888

CHEMICAL WORKS.

St. Louis Ammonia and Chem. Co.	Cincinnati, O.	One	18-ton	=18 tons	1886
Baugh & Sons Co.	Philadelphia, Pa.	One	12 "	12 "	1887
M. A. Seed Dry Plate Co.	St. Louis, Mo.	One	9 "	9 "	1887
M. A. Seed Dry Plate Co.—Second Order	St. Louis, Mo.	One	9 "	9 "	1890

CONFECTIONERS AND CHOCOLATE MFRS.

Gousset & Eller	New York	One	4-ton	=4 tons	1888
Croft & Allen	Philadelphia, Pa.	One	4 "	4 "	1889
Runkel Bros.	New York	One	4 "	4 "	1889

STEAMSHIPS.

*Oceanic Steamship Co.	Str. *Australia*	One	2-ton	=2 tons	1889

WINERIES,

American Champagne Co.	San Francisco, Cal.	One	9-ton	=9 tons	1889

ARTIFICIAL ICE PLANTS.

Name.	Address.	Number of Machines.		Total Ice-Making.	Year of Completion.
Bohlen-Huse Machine and Lake Ice Co.	Memphis, Tenn.	One	50-ton	=30 tons	1887
Bohlen-Huse Machine and Lake Ice Co.—Second Order	Memphis, Tenn.	One	50 "	30 "	1889
Buffalo Brewing Co.—Second Order	Sacramento, Cal.	One	50 "	30 "	1890
John R. Tendick	San Antonio, Tex.	One	35 "	20 "	
Count Albini	Rome, Italy	One	18 "	10 "	1887
Anheuser-Busch Brewing Ass'n—Fifth Order	Sherman, Tex.	One	18 "	10 "	1889
Anheuser-Busch Brewing Ass'n—Sixth Order	St. Louis, Mo.	One	220 "	130 "	1889
E. M. Barretto	Manila, Philippine Islands	One	9 "	5 "	1885
E. M. Barretto.—Second Order	Manila, Philippine Islands	One	9 "	5 "	1886
West Indian Ice and Refrigerating Co., Limited	Port of Spain, Trinidad Island, B. A. I	One	9 "	5 "	1885
J. L. Millsbaugh	Fort Concho, Tex.	One	4 "	2 "	1884
Edgar Fennell	Newport, Eng.	One	2 "	1 "	1890

252 Machines, equivalent in Tons of Ice melted each day, 11,277.

* Brine plants.
† Partly brine and partly direct-expansion plants.
All others are direct-expansion plants.

SUPPLEMENT.

MACHINES SOLD FROM JAN. 1 TO APRIL 1, 1890.

BREWERIES.

Name.	Address.	Number of Machines.		Total Refrigeration.	Year of Completion.
The Christian Moerlein Brewing Co.	Cincinnati, O.	One	100-ton. .	=100 tons. .	1890
St. Louis Brewing Ass'n, Cherokee Brewery Branch	St. Louis, Mo.	One	65 "	65 "	1890
Fred. Hower	Brooklyn, N. Y.	Two	35 "	70 "	1890
Christian Moerlein and Wm. Gerst.	Nashville, Tenn.	One	65 "	65 "	1890
Hinchliffe Bros	Paterson, N. J.	One	50 "	50 "	1890
George Brehm	Baltimore, Md.	One	50 "	50 "	1890
Herman Straub & Co.	Pittsburgh, Pa.	One	50 "	50 "	1890
The Grasser & Brand Brewing Co. —Second Order	Toledo, O.	One	35 "	35 "	1890
M. Winter Bros. (second order)	Pittsburgh, Pa.	One	65 "	65 "	1890
Oppman Brewing Co.—Second Order	Cleveland, O.	One	65 "	65 "	1890
Edward Habich Norfolk Brewery	Boston, Mass.	One	35 "	35 "	1890
George V. Muth	Cleveland, O.	One	35 "	35 "	1890
Indianapolis Brewing Co., P. Lieber Branch	Indianapolis, Ind	One	35 "	35 "	1890
George Hauck	Rondout, N. Y.	One	18 "	18 "	1890
Selig Manilla	Springfield, Mass.	One	18 "	18 "	1890

ABATTOIRS AND PACKING HOUSES.

T. M. Sinclair & Co.	Cedar Rapids, Ia	Two	100-ton. .	=200 tons. .	1890
Joseph Stern	New York	One	65 "	65 "	1890
Wm. H. Davis	Cincinnati, O.	One	35 "	35 "	1890
Jeremiah Murphy	St. Louis, Mo.	One	35 "	35 "	1890
Murray & Bro.	Rockaway B'ch, N.Y.	One	2 "	2 "	1890

COLD STORAGE.

Otto Huber Brewery—Third Order.	Far Rockaway, N. Y.	One	2-ton. .	= 2 tons. .	1890

HOTELS AND RESTAURANTS.

Iroquois Hotel.	Buffalo, N. Y	One	9-ton. .	= 9 tons. .	1890

CONFECTIONERS AND CHOCOLATE MANUFACTURERS.

Fobes, Hayward & Co.	Boston, Mass.	One	9-ton. .	= 9 tons. .	1890

ARTIFICIAL ICE-PLANTS.

				Total Ice-Making.	
William J. Lemp.—Third Order.	St. Louis. Mo.		Ice-Plant. .	=120 tons. .	1890
Corryville Artificial Ice Co.	Cincinnati, O.	One	100-ton	60 " . .	1890
A. Griesedieck Artificial Ice Co.—Second Order	St. Louis, Mo.	One	100 "	60 " . .	1890
Gottfried Krueger—Third Order.	Newark, N. J.	Two	100 "	120 " . .	1890
New York Hygeia Ice Co. (Limited.)	New York	Two	100 "	120 " . .	1890
New York Steam Co.	New York	One	100 "	60 " . .	1890
Otto Huber—Fourth Order	Brooklyn, N. Y.	One	65 "	30 " . .	1890
Montgomery Brewing Co.	Montgomery, Ala.	One	50 "	30 " . .	1899
John R. Tendick	San Antonio, Tex.	One	35 "	20 " . .	1890
St. Louis Brewing Ass'n, Klausman Brewery Branch—Second Order	St. Louis, Mo.		Ice-Plant. .	20 " . .	1890
St. Louis Brewing Ass'n, Schneider Brewery Branch—Third Order.	St. Louis, Mo.		Ice-Plant. .	30 " . .	1890
P. Ballantine & Sons—Fourth Order	Newark, N. J.		Ice-Plant. .	18 " . .	1890
Wm. Ottman.	New York		Ice-Plant. .	2 " . .	1890
Western Brewery Co.	Belleville, Ill.		Ice-Plant. .	20 " . .	1890

Those Desiring an Estimate for the Cost of a Plant will Please Note the Following:

THE insulation and other conditions vary considerably in different establishments, therefore it is impossible to compile a price-list for our plants.

In justice to our customers, as well as to ourselves, we prefer to examine the buildings and ascertain the actual work to be done, and thus collect sufficient data to enable us to guarantee that a given amount of work will be satisfactorily performed, and from which to make careful estimates of the cost of erecting machines of ample capacity.

Upon application we will make a survey of premises, and submit plans and specifications, with an estimate of cost of the plant, free of charge.

Parties located at a distance desiring to know by mail the probable cost of a machine, will please supply us with the following information:

1st. The length, width, and height of the rooms or cellars to be refrigerated. If the cellars are arched, give us the height to the centre and to the spring of the arches.

2d. What you desire to refrigerate. Please state exactly.

3d If a brewery, the number of barrels of wort to be cooled per day, and how rapidly you desire to cool it—that is, how many barrels per hour, and from what temperature down.

4th. If a packing-house or an abattoir, please state the number of carcasses to be cooled daily and their average weight.

5th. The temperature required in each room.

6th. The character, quantity, and temperature of the water at your disposal.

7th. Whether you desire to refrigerate by the direct expansion of the gas or by the circulation of brine.

8th. The annual consumption of ice heretofore.

Send a diagram of the establishment, that we may judge of the most economical plan of laying out the work, indicating upon it where you desire to locate your machine.

If you desire a plant for the manufacture of ice, state the number of tons of ice required as a daily production.